Formulas and Conversion Charts

A. Boiler Formulas

Boiler Horse Power (HP):

BHP = (Lb/hr) * FE / 34.5

where Lb/hr is pounds of steam per hour and FE is the factor of evaporation.

Cycle of Concentration of Boiler Water:

CYC=Bch / FCh

where Bch is ppm water chlorides and FCh is ppm feedwater chlorides.

Differential Setting (lb):

Delta S = P1 - P2

where P1 is the cutout pressure and P2 is the cut in pressure

Factor of Evaporation:

FE = SH + LH / 970.3

where SH is the sensible heat and LH is the latent heat.

Force (lb):

F=P / A

where P is pressure (psi) and A is area (in^2).

Horsepower (HP):

HP=(d * t) / (t * 33000)

where d is distance, F is force, and t is time.

Inches of Mercury (in):

InHG=P / 0.491

where P is pressure

Percent of Blowdown:

%BD=(PP - RP) / PP

where PR is popping pressure and RP is reseat pressure

Rate of Combustion (Btu/hr)

RC=H / (Vf * t)

where H is heat released (BTU), Vf is volume of furnace (ft^3), and t is time (hr).

Return Condensate Percentage in Feedwater

RC%=(MC – FC) / (MC – CC)

where MC is the makeup conductivity (μohms), FC is the feedwater conductivity (μohms), and CC is the condensate conductivity (μohms).

Static Head Pressure (lb)

SHP= Bpr * 2.31

where Bpr = boiler pressure (psi)

Steam:

S=HP * 34.5 * t

where HP is boiler horsepower and t is time (h).

Temperature Conversions:

F to C

C = (F – 32) / 1.8

C to F

F = (1.8 * C) + 32

Total Force (lb)

TF = P*A

where P is pressure (psi) and A is the area of valve disc exposed to steam (sq. in.)

Water Column (in)

WC = P / 0.03061

where P is pressure (psi).

B. Combustion Chemistry

Flue gas analysis:

Boiler flue gas analysis is used to determine combustion efficiency.	
Carbon Dioxide (CO2)	Indicates complete combustion
Carbon Monoxide (CO)	Indicates incomplete combustion
Oxygen (O2)	Indicates the presence of excess air
Oxides of Nitrogen (NOx)	A product of high temperature combustion
Combustibles	Material that burns when exposed to oxygen and heat

It is typical to target oxygen levels of 8% in low fire and 3% in high fire for gas fired burners.

It is typical to target oxygen levels of 6% in low fire and 4% in high fire for oil fired burners.

Johnston Boiler Company recommends no greater level than 200 ppm of Carbon Monoxide in its burner operation. The acceptable “Industry Standard” level is 400 ppm or less.

Johnston Boiler Company recommends zero combustibles for a gas fired burner.

Johnston Boiler Company recommends a maximum #2 Smokespot (Ringelmann Chart) in its oil fired burner.

Air Properties:

For a burner originally adjusted to 15% air, changes in combustion air temperature and barometric pressure cause the following in excess air:

Air Temperature	Barometric Pressure (In. HG)	Resulting Excess Air %*
40	29	25.5
60	29	20.2
80	29	15.0
100	29	9.6
120	29	1.1
80	27	7.0
80	28	11.0
80	29	15.0
80	30	19.0
40	31	34.5
60	30	25.0
80	29	15.0
100	28	5.0
120	27	-5.5

* Expressed as a percent of the Stoichiometric air required.

C. Energy Loss From Scale Deposits

ENERGY LOSS FROM SCALE DEPOSITS IN BOILERS	
SCALE THICKNESS (INCHES)	EXTRA FUEL COST (PERCENT)
1/32	8.50
1/25	9.30
1/20	11.10
1/16	12.40
1/8	25.00
1/4	40.00
3/8	55.00
1/2	70.00